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Watershed Program Evaluation

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KIOWA CREEK, COLORADO

interim progress report

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AGRICULTURAL RESEARCH SERVICE
SOIL CONSERVATION SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
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WATERSHED PROGRAM EVALUATION

KIOWA CREEK, COLORADO

Interim Progress Report

SOIL CONSERVATION SERVICE

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WATERSHED PROGRAM EVALUATION

KIOWA CREEK, COLORADO

Interim Progress Report

SUMMARY

The Kiowa Creek watershed is a foothill area with steep slopes in which cloudbursts are common. The interest and determination of farmers and ranchers and their cooperation with the Kiowa Soil Conservation District resulted in the establishment of the Kiowa Creek Watershed Protection Project in 1954. The work plan of the project included a supplement for program evaluation.

The purposes of the evaluation program are to estimate and measure:

(1) Soil and water conservation benefits;

(2) Benefits from reduced damage by floodwater and sediment; and

(3) Benefits from increased crop yields resulting from the more intensive use of flood-plain land associated with flood prevention.

Agencies participating in the evaluation program are the Weather Bureau, Geological Survey, Agricultural Research Service, and Soil Conservation Service. The physical effects and monetary values of soil and water conservation and floodwater and sediment control are being measured, studied, and interpreted. In accord with the evaluation plan, measuring devices to record streamflow, sedimentation, and precipitation, and for study of selected floodwater-retarding reservoirs had been installed by the end of 1956. A study of the economic effects of the project is underway. The current authorization for evaluation extends to July 1, 1961. It is hoped that these studies will be continued beyond this date.

At the inception of the project there were 101 farms and ranches wholly or partly within the 75,520-acre area. As of June 30, 1958, about 56 percent of the needed land-treatment measures had been applied to the land, about half of them since 1954. This progress was made despite four successive drought years before 1957. Seventy-eight farmers controlling 92 percent of the watershed were cooperating with the Kiowa Soil Conservation District. Forty-four farms covering 52 percent of the area had basic soil and water conservation plans.

Structural measures installed as of June 30, 1958, include 34 of the 64 floodwater-retarding structures planned, 2 of the 30 stabilizing and sediment-control structures, and 12,300 linear feet of the needed 19,200 linear feet of channel improvement.

Air view of project, looking downstream at Elbert. White area shows sandy waste in creek channel. (SCS neg. Co-3874-11.)

Contract cost for construction of the first 34 structures completed was $259,436. By June 30, 1958, eighteen other floodwater-retarding structures were designed and were in the invitation-to-bid and contract stage.

Total flood-prevention benefits attributable to installed works of improvement through 1957 amount to $23,652. Of this total $21,390 was due to reduction of flood damages and the remainder was from more intensive use of 70 acres of land in the flood plain.

INTRODUCTION

The Kiowa Creek Watershed Protection Project is being carried out under the authority of the Soil Conservation Act of 1935 (Public Law 46, 74th Congress) as implemented by the watershed-protection item in the United States Department of Agriculture Appropriation Act of 1954. This act included an initial appropriation of $5,000,000, and authorized a total of $28,706,000, for a pilot watershed program. The program was initiated in 62 small upstream areas, representing a wide range of conditions, and 7 of these were subsequently deauthorized at the request of the local sponsors. These pilot projects were intended to demonstrate the practical worth of complete watershed protection in conserving soil and water resources and in preventing damage from floods and sedimentation.

The Kiowa pilot project is one of 10 selected for intensive evaluation of results. The broad objective of these evaluations is to measure the effectiveness of the applied programs in both physical and economic terms. Studies are being made as to benefits resulting from:

(1) Reduction of floodwater and sediment damages;

(2) Changes in runoff characteristics;

(3) Changes in crop and forage production; and

(4) Changes in the economy of the area.

A work plan for the Kiowa Creek Watershed Protection Project was developed in 1954, including a supplement for program evaluation. This plan was further developed and amended in 1956.

People in the project area have been interested in soil conservation and flood-control measures for many years. In June 1941, the Kiowa Soil Conservation District, sponsor of this pilot project, declared in its work plan: "The purposes for which this district is organized are to control floods and erosion, and to develop and establish a general system of soil conservation and improved land use practices."

Leaders in the area formed the Quint Valley Flood Prevention Association in the late forties. This 5-county voluntary association led an active

movement toward accomplishing watershed-control measures. The group was interested in obtaining a pilot project, and it is now interested in evaluation of the program. Active interest of people in the watershed is demonstrated by the fact that 92 percent of the area is covered by rancher-district cooperative agreements.

PREPROJECT CONDITIONS

Watershed Problems

Erosion, floodwater, and sediment damages are major problems in the Kiowa Creek watershed area. The watershed is subject to rainstorms of high intensity and short duration. This type of storm on steep slopes produces flash floods with comparatively small volumes of water.

The Kiowa watershed headwaters area is partly timbered, rolling to rough upland, broken by numerous gullies. Average fall of the main channel is about 50 feet per mile and side drainages fall from 100 to 200 feet per mile. Eighty percent of the cultivated upland has been affected by erosion. Erosion is a critical problem on the class VI and VII lands that are under cultivation. Farming such land has resulted in both sheet and gully erosion. Gullies extend through the cropland and into the rangeland and forested areas.

In addition to onsite land damage from erosion there is considerable flood-plain damage from deposition of silt, sand, and other materials carried by floodwaters. This sediment, which is composed mainly of infertile sand, has been left on the fertile lands of the flood plain in deposits that range in depth from a few inches to 6 feet. Moderate to heavy deposits not only destroy the current crop but may make the land unproductive until the sediment is removed. Cost of such reclamation varies from $50 to $150 per acre. Before inception of the project, little of this type of reclamation had been undertaken because of the danger of recurring floods.

Damage from sedimentation may be local in nature, the amount and location of sedimentation depending on the vicinity and intensity of the rains. Any high-intensity rain causes deposition of sediment in some stream areas and bank cutting in others. As the floods recede severe bank cutting may occur. A flood on a single subwatershed may cause considerable change in flow characteristics of the main creek channel.

Floodwater and sediment damages along Kiowa Creek do not result from slow-moving water as is true on creeks with flatter stream gradients. Damages result from high-velocity waters that cause severe cutting and leave heavy loads of infertile sediment as the flood recedes. During the 20 years before the inception of the project, such damages decreased production substantially on more than 2,000 acres of subirrigated bottom lands along Kiowa Creek. The use of 12 direct-flow water rights was lost within the last 30 years because diversions could not be maintained.

An inventory of the use of the flood plain was developed by mapping the use of each field on aerial photographs. All major fixed improvements subject to flood and sediment damages were also indicated on the photographs. Major land uses in 1954 are summarized in table 1. The major crops grown in the flood plain in 1954 are listed in table 2.

Table 1. - Acreages of crops, pasture, and wastelands in the flood plain, Kiowa Creek Watershed Protection Project, 1954 farm survey

Land use	East Kiowa Creek	West Kiowa Creek	Main Kiowa Creek	Total
	Acres	Acres	Acres	Acres
Cropland	805	866	1,049	2,720
Pasture	613	1/ 1,207	762	2,582
Waste and stream channel	326	1/ 400	662	1,388
Farmsteads, roads, and fences	45	41	64	150
Total flood plain	1,789	2,514	2,537	6,840

1/ Estimates.

Table 2. - Major uses of cropland in the flood plain, Kiowa Creek Watershed Protection Project, 1954 farm survey

Land use	East Kiowa Creek	West Kiowa Creek	Main Kiowa Creek	Total
	Acres	Acres	Acres	Acres
Crop acreage	805	866	1,049	2,720
	Percent	Percent	Percent	Percent
Forage crops	68	50	80	67
Feed grain	7	4	10	7
Seeded grasses	10	22	2	11
Cash grain	4	3	4	4
Idle and fallow	11	21	4	11
Total	100	100	100	100

Runoff, erosion, and sediment characteristics of the watershed had a major influence on preproject use of the flood plains. In 1954, 20 percent of the total flood plain area was either wasteland or part of the stream channel, 40 percent was in cropland, 38 percent in pasture, and 2 percent in other uses.

The cropping system in the flood plain is developed to support livestock enterprises. In 1954, 67 percent of the cropland was used to raise roughage for livestock, including such crops as alfalfa, corn silage, sudan and cane, small-grain hay, and meadow hay. Eleven percent was in seeded grasses that could be cut for hay or used for pasture; 7 percent was used to raise feed grains; and 11 percent was summer fallowed or remained idle. Only 4 percent of the cropland was used to raise such cash crops as wheat and dry field beans. Owing to the loss of some feed crops because of floodwaters, this was frequently a feed-deficit area.

In addition to the farm survey of 1954, a complete inventory was made of all man-made structures in the project area that were subject to flood damage. This inventory lists one-half mile of roads, 1,420 feet of bridges, 6 culverts, 40 utility poles, 3 corrals, 10 buildings, 14,830 feet of dikes, and 7 irrigation wells and pumps that could be damaged when the streams reach flood stage. Each item of the inventory was given a code number and was cross-referenced to a map showing the exact location. With this inventory and map, it is easy to locate the man-made structures in the flood plain.

Before the inception of the project, the lower reaches of the project area were subject to flash floods and sediment damage in most years as a result of intense storms on some part of the watershed. When an intense storm covered a large part of the watershed, major floods occurred. Major floods of recent years occurred in 1920, 1921, 1925, 1933, 1935, and 1945. The most severe of these was the flood of 1935, which took 7 lives and caused property damage of more than $2,000,000, including abandonment of the branch line of the Colorado and Southern Railway, which ran through about two-thirds the length of the watershed. Extensive flood damage to railroad bridges and tracks made it uneconomical to resume operations.

Direct floodwater and sediment damage in the project area was estimated to have averaged $49,550, not including the 1935 railroad damage. Indirect losses to business and interruptions of travel are estimated at $4,950, making total average annual damages of $54,500. Estimates of annual flood damages in preproject years are itemized below:

Type of damage	Dollars
Floodwater:	
Crop and pasture	3,390
Flood plain scour	4,320
Channel scour	15,710
Other agricultural	7,500
Roads and bridges	5,580
Subtotal	36,500

Sediment:

Flood plain deposition	13,050
Indirect	4,950
Subtotal	18,000
Total average annual damage	54,500

Physical Characteristics

Soils of the watershed are generally sandy and erodible. They are developed principally from the Dawson formation, with small areas in the higher reaches developed from Castle Rock conglomerate. They are shallow in the headwaters area and become deeper downstream. Most of the cultivated soils have a medium-textured topsoil with moderate permeability and depths of 20 to 36 inches. Flood-plain soil that has not been damaged by floods is fertile and easily worked.

Precipitation records have been kept by the Kiowa State Bank since 1921. From 1921 to 1954, average annual precipitation as recorded from this gage was 16.6 inches, with a low of 6.91 in 1939 and a high of 24.04 in 1947 (fig. 1). Most precipitation comes in the form of rain from April through August. Most rains are of high intensity and short duration. The frost-free growing season varies according to elevation (6,348 feet to about 7,800 feet), and averages about 123 days. Late spring frosts are not uncommon.

According to the 1954 farm survey, land in the project was about 18 percent in cropland (13,660 acres) and 82 percent (61,860 acres) in pasture or other uses (table 3). This was fairly typical of the two counties, Elbert and El Paso, in which the project is located. Cropland in Elbert County was 21 percent of all land, and in El Paso County it was 13 percent. The ratio of pasture to total cropland emphasizes the importance of livestock enterprises in the area.

The total project area delineated in the work plan covers 75,520 acres. In 1954, there were about 10,940 acres of upland cropland, used chiefly for wheat and small grain, and 2,720 acres of cultivated flood plain, mainly in hay. The average condition of the 59,800 acres of grassland was considered to be "fair." Of this grassland acreage, 14,500 acres were timbered, and 8,000 acres consisted of land that had once been farmed and was in various stages of natural or seeded vegetation. There were 6,544 acres of cultivated class VI and VII land that were unsuitable for farming, and 8,000 acres of abandoned land that should be seeded for best use.

Status of Conservation

At the inception of the project, there were 101 farm or ranch units that had land within the watershed. As of January 1, 1954, operators of 48 units with 46,850 acres were cooperating in the Kiowa Soil Conservation

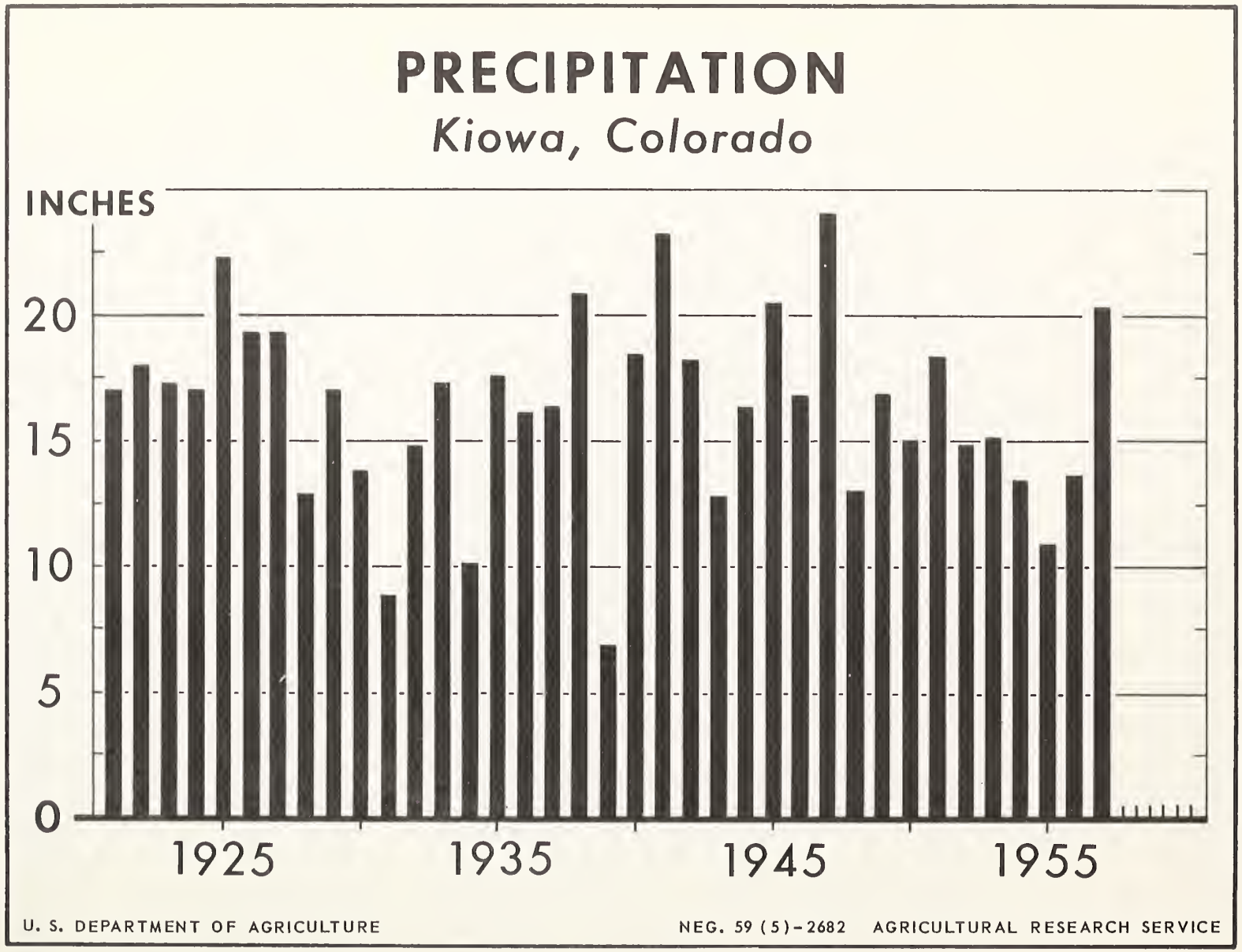

PRECIPITATION
Kiowa, Colorado
INCHES
20
15
10
5
0
1925
1935
1945
1955
U. S. DEPARTMENT OF AGRICULTURE
NEG. 59 (5)-2682 AGRICULTURAL RESEARCH SERVICE

Figure 1

Table 3. Land use, Kiowa Creek Watershed Protection Project, 1954 farm survey

Land use	Flood plain	Upland			Total
		East Kiowa Creek	West Kiowa Creek	Main Kiowa Creek	
	Acres	Acres	Acres	Acres	Acres
Cropland	2,720	2,290	2,280	6,370	13,660
Pasture	2,582	12,115	22,206	22,897	59,800
Waste and stream channel	1,388	---	---	---	1,388
Farmsteads, roads, and fences	150	142	205	175	672
Total	6,840	14,547	24,691	29,442	75,520

District Program. Of these, 34 had basic plans covering a total of 31,906 acres.

A Civilian Conservation Corps camp was established within the project area following the disastrous flood of 1935. Considerable work, such as contour furrowing, and building of stock-water dams, gully-control structures, and diversions, was accomplished before the camp was discontinued in 1942. During World War II there was little conservation activity. Conservation work was just beginning to get underway again when the 1953 and 1954 drought years slowed down application of land-treatment measures.

Water Conservation and Use

Significant loss of water on fields and pastures occurs through runoff if it is not controlled by mechanical measures such as contour furrows or retarded by vegetation. Before 1954, 7,260 acres of contour furrows had been established. Ninety-eight dams had been constructed, most of them for stock water. A few were open-pipe dams installed for erosion control.

Individual wells provided water for domestic use in the towns of Kiowa and Elbert.

There are 27 irrigation water filings on the entire Kiowa Creek drainage, claiming 700 cubic feet per second of direct flow. Of this flow, only 31 cubic feet per second is within the project area. Since the flood of 1935, use from any of these filings has been limited. Channel changes have made it difficult and even impossible at times to maintain diversion structures and main ditches. Irrigators report that in the Kiowa Valley below the project area, sediment carried by floodwater is detrimental to irrigation because it seals and crusts the surface of the soil.

The first irrigation well in the project area was drilled in 1940, and seven additional wells were drilled from 1947 to 1953. In 1954, these wells had an estimated capacity of 100 to 500 gallons per minute. About 400 acres were irrigated from pumps.

Watershed Economy

Size of farms in the project area in 1954 ranged from less than 20 to 11,000 acres (table 4). Nearly 80 percent of the 92 farms in the farm survey contained between 261 and 2,000 acres. The most common size of farm was 261 to 560 acres in the Main Kiowa subarea, 561 to 880 acres in the East Kiowa subarea, and 881 to 2,000 acres in the West Kiowa subarea. No farm lies entirely within the flood plain of the project area, but some farms lie entirely within the upland. In the total watershed area, 10 percent of all farms contained 260 acres or less; 57 percent contained 261 to 880 acres; 22 percent contained 881 to 2,000 acres; and 11 percent contained more than 2,000 acres.

Table 4. - Number and percentage distribution of farms, by acreage group, subareas, Kiowa Creek Watershed Protection Project, 1954 farm survey

Size of farm (acres)	East Kiowa Creek		West Kiowa Creek		Main Kiowa Creek		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
20 to 260	4	19	3	12	2	4	9	10
261 to 560	3	14	5	19	22	49	30	32
561 to 880	7	34	5	19	11	25	23	25
881 to 2,000	4	19	11	42	5	11	20	22
2,001 to 11,000	3	14	2	8	5	11	10	11
Total	21	100	26	100	45	100	92	100

This is a livestock grazing area, and livestock is the major enterprise in each of the three subareas. It was the major source of income for at least 84 percent of the farm units in 1954 (table 5). On 36 percent of the farms beef cattle were the major source of income. Second in importance was dairying, which was the major enterprise on 33 percent of the farms. Most of the milk was picked up by motor truck and taken to Colorado Springs. The remaining livestock farms, 15 percent of the total, had beef cattle or sheep in conjunction with dairying, and each of the livestock enterprises was an important source of farm income. Cash-crop farms comprised only 16 percent of the total. Wheat was the major cash crop.

Weighted-average yields of the major crops in the project area for the years 1951 through 1954 are shown in table 6 for irrigated and dryland farming

Table 5. - Number and percentage distribution of farms, by major enterprise, subareas, Kiowa Creek Watershed Protection Project, 1954 farm survey 1/

Major enterprise	East Kiowa Creek		West Kiowa Creek		Main Kiowa Creek		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Beef cattle	7	41	6	30	14	36	27	36
Dairy	5	29	7	35	13	33	25	33
Beef-dairy	1	6	5	25	5	13	11	14
Sheep-dairy	0	--	0	--	1	3	1	1
Cash-crop	4	24	2	10	6	15	12	16
Total	17	100	20	100	39	100	76	100

1/ 16 farms omitted because of insufficient information.

Table 6. - Average yields per acre of major crops, Kiowa Creek Watershed Protection Project, 1954 farm survey, 1951-54 1/

Crop	Unit	Flood plain		Upland	Project area
		Irrigated	Dryland		
Alfalfa	Ton	2.1	0.8	1.0	1.1
Corn, ensiled	do.	10.2	4.3	3.5	4.4
Small-grain hay	do.	---	1.4	.7	.9
Oats	Bushel	---	14.2	12.0	12.3
Barley	do.	---	2/ 8.1	2/ 8.9	2/ 8.8
Wheat	do.	---	14.5	13.4	13.4

1/ Weighted average.
2/ Adjusted upward by 2 bushels from farmers' estimates to allow for hail damages and the fact that a very small nonrepresentative acreage was grown.

and for farming in the upland area. These yields are fairly representative of the surrounding area. For example, average yields in Elbert and El Paso Counties from 1946 to 1956, as shown in Colorado Agricultural Statistics, 1/ were, respectively, 1.4 and 1.7 tons of alfalfa, 14.0 and 13.2 bushels of dryland oats, 10.8 and 9.4 bushels of dryland barley, and 12.5 and 12.5 bushels of dryland wheat. Average yields of forage corn, and small-grain hay were not available.

1/ Colorado Department of Agriculture, Colorado Agricultural Statistics. Vol. 2, No. 3, pp. 34-35. Apr. 1958.

Gross farm income for farms surveyed was estimated for 1954, using average sale prices per unit of cash crops and gross sales per unit of inventoried classes of livestock for Elbert and El Paso Counties. These sales per unit were multiplied by the respective production and inventoried items shown in the 1954 farm survey. This method gave a gross farm income for 1954 of $509,040. This may be lower than the long-time average of the area because in 1954 wheat yields were low, feed supplies had been short for 3 years, and on most farms, numbers of livestock were less than the operators considered "normal." The average gross farm income ranged from $1,244 for farms of less than 260 acres to $18,901 for farms of more than 2,000 acres (table 7).

Table 7. - Gross farm income estimated by size of farm, Kiowa Creek Watershed Protection Project, 1954 farm survey

Size of farm (acres)	Farms	Gross farm income -	
		Per farm	Per acre
	Number	Dollars	Dollars
20 to 260	9	1,244	7.11
261 to 560	30	2,501	6.18
561 to 880	23	4,036	5.66
881 to 2,000	20	7,048	5.56
2,001 to 11,614	10	18,901	4.90
All farms	92	5,533	5.42

Average gross farm income per acre of total land ranged from $7.11 on small farms to $4.90 on large farms. This lower gross farm income per acre for larger units does not necessarily mean less efficiency as compared to smaller farms, but rather it reflects the lower productivity per acre of some of the land included in the larger units. On a proportionate basis, the larger units have less cropland and more pasture than smaller farms.

PLANNED PROGRAM OF IMPROVEMENT AND ESTIMATED BENEFITS

Estimated quantities of land-treatment measures needed in the project area were developed by use of technical guides based on conservation surveys. It was assumed that these estimated quantities could be completed by farmers and ranchers during the 5-year installation period of the project. However, because of 4 consecutive years of drought, the sponsor obtained a 2-year extension of the installation period to give local ranchers more opportunity to complete application of land treatment. Land-treatment measures include such practices as seeding cultivated and abandoned cropland to grass; grass

management; furrowing or pitting of rangeland; construction of small erosion-control and stockwater dams; terracing, stubble mulching, stripcropping, and contour farming on cropland; and, on the Ponderosa Pine timberland, woodland-management measures. Table 8 shows the quantities of land-treatment measures installed before the inception of the program, and the quantities of measures to be installed during the 7-year installation period. Funds were allocated to provide an additional technician to accelerate the application of land-treatment measures.

Installation of a system of 64 floodwater-retarding structures and 30 stabilizing and sediment-control structures was planned. When the program is complete, the runoff from about 64 percent of the watershed will be regulated. The floodwater-retarding structures are designed to regulate the volume of runoff from all 1-hour storm periods having a reoccurrence interval of 25 years. Sediment capacity for 50 years is provided in each floodwater-retarding structure. In addition to an emergency spillway, ungated outlet tubes will release detained floodwater in 24 to 48 hours. Channel-improvement work is planned for 15,000 lineal feet of channel.

Other measures incident to a watershed protection program and having an indirect effect on flood prevention were included in the project plan. These include wildlife-area improvement, rehabilitation of bottom meadows, and water conservation and improved cropping practices on irrigated lands.

It is estimated that the planned land-treatment measures, together with the structures for retarding floodwaters and controlling sedimentation, will reduce average annual damages by approximately 77 percent, a reduction from $54,500 without the project to $12,370 with the project. In addition to this damage reduction of $42,130, benefits from intensification of land use in the flood plain are expected to be about $21,980, making total benefits of $64,110. It was estimated that conservation benefits to landowners and operators in the upland area will amount to $46,960 annually.

PROGRESS TOWARD COMPLETION OF PLANNED PROGRAM

Land-Treatment Measures

As of June 30, 1958, the Kiowa Soil Conservation District, the sponsoring organization for the project, had agreements with 78 cooperators holding a total of 69,763 acres. This is 92 percent of the 75,520 acres in the project area. Forty-four of the cooperators had basic plans, covering 39,295 acres, or 52 percent of the area. Watershed land is managed within 101 operating units. Eleven of these units have 100 acres or less in the project area.

The land-treatment phase of the planned program was seriously delayed because of the prolonged drought which began in 1953 and continued throughout 1954, 1955, and 1956. Farmers were unable to spend money for conservation work at a time when the chance for financial return was small and funds were urgently needed for living expenses.

Table 8. - Progress of installation of works of improvement, Kiowa Creek Watershed Protection Project, June 30, 1958

Works of improvement	Unit	Total needs	As of 1954		As of June 30, 1958	
			Completed	To be completed	Completed since 1954	To be completed
Structural measures:						
Floodwater-retarding structures	Number	65	1	64	34	30
Stabilization and sediment-control structures	do.	30	0	30	2	28
Channel improvement	Linear foot	19,200	4,200	15,000	8,092	6,908
Land-treatment measures:						
Pasture and range seeding	Acre	9,110	3,210	5,900	1,920	3,980
Contour furrowing	do.	12,000	7,260	4,740	856	3,884
Structures, erosion control	Number	285	100	185	13	172
Livestock-water ponds	do.	133	98	35	20	15
Range improvement	Acre	58,000	0	58,000	35,125	22,875
Fencing	Mile	50	25	25	0	25
Terraces	do.	55	5	50	12	38
Field diversions	do.	65	5	60	24	36
Waterway development	Acre	200	30	170	21	149
Contour farming	do.	3,000		2,000	0	2,000
Stubble mulching	do.	2,000	1,000	1,000	0	1,000
Stripcropping	do	1,500		500	0	500
Woodland management	do.	10,000	0	10,000	2,372	7,628

Greatest progress in land-treatment measures has been made in the range-management and grass-seeding practices. Although there is still much to be accomplished in each practice, progress is good when considered in light of the number of small farm units in the area. It will be difficult, if not impossible, to get complete conservation on some farms that cannot support a family and on which farming would continue to be uneconomic even if all needed conservation practices were carried out.

Of the 23 noncooperators in the project area, only 2 have units of more than 500 acres - one unit contains 520 acres and one 920 acres. The other noncooperators are part-time farmers and holders of leased land and land used mainly for nonagricultural use, such as country residences and very small farms.

Progress in installing works of improvement is summarized in table 8. As of June 30, 1958, practices accomplished since inception of the project plus those applied before inception totaled about 56 percent of the land-treatment measures called for in the project plan.

Structural Measures

The project plan, as revised, calls for installation of 64 floodwater-retarding structures, of which 34 had been installed by June 30, 1958, and of which 30 were scheduled for construction by June 30, 1960. Only 2 of the 30 planned stabilization and sediment-control structures had been constructed. Some 8,092 linear feet of channel improvement had been completed, leaving 6,908 linear feet remaining to be done. Data regarding floodwater-retarding structures installed as of June 30, 1958, are shown in table 9.

Local Contributions

In addition to farm costs of land-treatment measures that have been applied, the value of local contributions of goods and services totaled $65,394 as of July 1, 1958, as tabulated below:

Office expense and Board activities	$ 3,800
Easements and rights-of-way (estimated value)	39,360
Construction of 1 floodwater-retarding structure	12,815
Construction of 1 detention structure	2,555
Construction of 2 sediment-control structures	1,750
Other construction costs	4,176
Maintenance costs on site K-79	938
	$65,394

PURPOSE AND PLAN OF PROGRAM EVALUATION

Objectives

The broad objective of the Kiowa evaluation plan is "to evaluate the effects of the watershed protection program in both physical and economic terms." The plan stated further: "To do this properly it will be necessary to measure various physical and economic factors within the watershed and the

Table 9. - Progress in installation of floodwater-retarding structures, Kiowa Creek Watershed Protection Project, June 30, 1958

Site number	Drainage area	Storage capacity			Maximum height of dam	Volume of fill	Construction cost (contract)
		Sediment pool	Detention pool	Total			
	Square miles	Acre-feet	Acre-feet	Acre-feet	Feet	Cubic yards	Dollars
B-9--------	0.65	13.99	26.30	40.29	22.3	15,750	6,114.25
C-11-------	.46	6.90	18.50	25.40	23.9	10,219	5,177.23
D-12-------	1.10	14.75	31.80	46.55	25.7	18,876	7,337.77
E-17-------	.23	.67	8.90	9.57	14.9	3,818	1,630.50
G-20-------	.08	1.84	3.60	5.44	12.4	2,872	1,630.20
H-21-------	.96	3.00	35.31	38.31	23.3	17,336	9,151.40
I-28-------	.33	2.17	13.50	15.67	20.3	8,146	3,283.37
J-33-------	1.07	2.93	39.40	42.33	23.0	15,541	7,508.39
K-38-------	.38	2.38	15.40	17.78	21.8	8,266	4,529.47
K-39-------	.17	.86	8.00	8.86	16.5	4,562	1,805.47
K-40-------	.16	.86	7.60	8.46	16.8	7,133	2,129.15
K-41-------	.31	1.50	13.70	15.20	19.6	7,252	3,743.53
K-79-------	3.56	23.00	99.30	122.30	33.2	35,165	14,621.29
L-42-------	.42	1.81	20.20	22.01	18.9	12,629	5,821.54
O-46-------	.27	.90	7.90	8.80	15.5	7,546	2,395.83
P-47-------	1.01	9.80	36.90	46.70	18.4	23,103	7,866.74
Q-51-------	.56	12.06	24.20	36.26	35.0	10,320	13,845.35
R-3--------	2.91	50.24	103.10	153.34	25.3	25,074	10,526.78
V-67-------	1.45	6.47	52.50	58.97	22.2	20,468	8,412.50
W-71-------	.32	.30	13.00	13.30	20.7	8,515	4,343.86
X-73-------	.50	2.42	19.70	22.12	18.3	6,834	3,415.60
Y-77-------	.23	1.67	10.00	11.67	16.1	4,447	2,356.54
1-G-20-----	.88	11.40	32.80	44.20	25.6	17,937	7,492.48
1-G-30-----	1.66	9.30	61.50	70.80	23.5	16,858	7,126.30
1-M-10-----	.94	8.00	35.20	43.20	22.4	13,994	6,263.94
1-N-10-----	1.42	10.50	50.50	61.00	23.2	29,640	10,383.83
2-D-20-----	.82	5.43	30.60	36.03	25.2	19,082	8,948.60
2-G-10 1/--	1.42	21.36	53.00	74.36	28.6	32,953	12,815.13
2-G-20-----	.30	3.35	12.30	15.65	15.5	9,377	4,264.46
2-G-30-----	.18	1.03	7.60	8.63	14.4	5,530	3,045.08
3-B-10-----	1.11	14.80	36.50	51.30	21.1	19,185	8,584.50
3-B-40-----	1.64	24.18	57.70	81.88	32.2	25,519	11,639.87
3-B-60-----	.93	24.05	34.20	58.25	25.4	18,361	8,584.90
3-D-10-----	7.84	112.00	242.50	354.50	31.2	109,464	42,640.18
Total--	36.27	405.92	1,263.21	1,669.13	----	591,772	259,436.03

1/ Constructed by sponsor.

Floodwater-retarding structure 3D-10 completed summer 1958. Drainage area 5,017 acres. (SCS neg. Co-4701-1.)

Close-up view of outlet tube with anti-vortex baffle. (SCS neg. Co-4701-7.)

changes brought about in them by the application of the program. This will include changes in runoff characteristics, flood and sediment damages, and crop and forage production resulting from soil and water conservation improvement. The specific objectives of the evaluation studies will be to test the effectiveness of the works of improvement and the annual benefits, which are estimates."

The original evaluation plan was amended in 1956 to provide for the additional equipment and instrumentation needed to ensure proper measurement of annual benefits. The evaluation will now be carried through the fiscal year 1961, and it is hoped that means will be provided to continue the effort beyond that date.

It is expected that results of this and similar evaluations will provide a sound basis for improvement in planning and installation of watershed-protection and flood-prevention projects.

Procedures

Instrumentation. - Measuring devices were needed to record precipitation, streamflow, and sedimentation so that hydrographs could be developed, relationships ascertained between precipitation and runoff, and a basis obtained for estimating damage reduction.

Rain gages were installed in selected locations. Crest-stage gages were installed above and below five selected floodwater-retarding structures and at other points in stream channels. A combination streamflow gage and sediment-load station was installed near the town of Elbert on East Kiowa Creek and another near Kiowa on the main channel. Water-stage recorders were installed in the five selected reservoirs. By June 1958 the following installations were in place:

4 recording rain gages
10 standard rain gages
2 stream-gaging and sediment-load stations (combination)
5 water-stage recorders in selected retarding reservoirs
14 maximum stream-crest gages
100 permanent monuments to facilitate resurveys of established cross sections

These devices will provide a basis for estimating peak flows, amount of land inundated, and amounts of sedimentation that would have occurred without the project. The map attached, revised as of January 1, 1959, shows instrument locations in relation to works of improvement. Instrumentation was concentrated on East Kiowa Creek because of the location of initial structures in this drainage area. (See map in pocket of back cover.)

Range-study plots. - Study of changes in range conditions is underway in the subwatersheds above each of the five reservoirs (B-9, J-33, K-79, Q-51, R-3) selected for evaluation. For each subwatershed, adjacent plots on typical range sites, one plot fenced and one unfenced, each 100 x 100 feet, were

chosen for study. Line-transect readings were taken on these plots in 1956 to record plant composition as of that date. Forage-clipping studies are made and recorded on all plots annually. At the end of 5 years, the line transects will again be read to determine any change in composition. It is expected that infiltration tests will be made to provide additional information on runoff characteristics.

Water table. - Observations of water level in 10 wells in the project area have been carried on since 1955 and will be continued in order to learn the effects of the project on ground-water level.

Stream-channel stability. - A special study of the effect of water released from floodwater-retarding structures on the channel of East Kiowa Creek is being conducted by consultant Dr. Vito A. Vanoni with assistance from the Soil Conservation Service. The study is nearly complete. The final report will be prepared by Dr. Vanoni.

Trap efficiency study. - A special study of reservoir K-79 is under way cooperatively between the Geological Survey and the Soil Conservation Service. The Geological Survey has made a report of progress as of June 1958.

Economic inventory. - An economic inventory was made to describe watershed conditions prior to the development of the project. It will provide a benchmark from which most benefits will be measured. The farm survey conducted in 1954 indicated the farm resources available and how they were used. All fields were delineated on aerial photographs and the use of and yield from each field were estimated. Livestock numbers and use of each pasture were recorded. In addition, an inventory of all fixed improvements in the flood plain was made, and each item on this inventory was located on a map. The inventory of improvements on the flood plain will be used as a basis for estimating damages from actual floods or floods that would have occurred without the project. It is planned to evaluate all changes in terms of dollars and to estimate the benefits and costs of the program not only for the project as a whole, but also for subwatershed areas wherever the benefits can be identified definitely with specific works of improvement.

Changes of land use and crop yields in sample areas. - Sample areas were selected for annual study of changes in land use, land-treatment measures and costs, and crop yields. These sample areas include the flood plain along East Kiowa and Main Kiowa Creeks and eight upland areas. The flood-plain areas will be surveyed to discover changes in land use and yields that are brought about when flood-prevention structures reduce the risk of damages from floods. Production and costs incurred in changes in land use are noted, including those for 1-acre tracts. Damages are recorded also. Benefits and costs will be evaluated in terms of prices prevailing during the year of their incidence.

The eight upland sample areas are scattered throughout the watershed. Five are located above structures with hydrological measuring devices. Six are located one on either side of the three subdrainage areas. As in the flood plain, information is obtained annually on these upland sample areas.

Most of the changes in land use and yields in the upland areas will result from land-treatment measures that are adopted by the farmers.

Cost of land-treatment measures. - Data are being assembled on the costs of different land-treatment measures. Where land-treatment measures are installed under contract, the cost to the farmer is relatively easy to ascertain, but if the farmer installs his own land-treatment measures, information on cost is more difficult to obtain. Seven farm records were taken to find the costs, problems, and limitations of land-treatment measures.

Benefits from reduction in floodwater and sediment damage. - Each year, with few exceptions, intense rains cause varying amounts of damage. Damages to crops and improvements are appraised and reported annually. As the project is developed by the construction of flood-prevention structures and land-treatment measures, rains of comparable intensity become less destructive. The plans for estimation of benefits include utilization of hydrological and engineering information to discover what areas and fixed improvements would have been subject to damage if the respective work of improvement had not been installed. However, thus far, tentative appraisals of flood-prevention benefits have been made by reconnaissance methods shortly after flood occurrences. These estimates, in terms of prices prevailing during the years the floods occurred, will become a part of the benefits attributed to the project.

Limitations

The economic evaluation needs to be continued for a number of years to learn more precisely the effects of watershed protection and flood-prevention measures. This appraisal is needed to formulate recommendations and guides for future projects in similar watersheds. The economic evaluation if terminated in the fiscal year 1961 will provide only a small part of the information needed to measure adequately the physical effects of the installed works of improvement.

FINDINGS OF PROGRAM EVALUATION TO DATE

Gage Records and Other Physical Measurements

Gage Records

Through cooperative arrangements with the U. S. Weather Bureau, 10 standard rain gages and 4 recording rain gages were installed late in 1954 at selected points throughout the watershed. Local farmers and ranchers were enlisted as observers. During 1955, some difficulty was experienced with the clocks on the recording gages, and they were later replaced. A few of the observers also failed to make regular observations or did not turn in monthly reports. As a result of faulty equipment and failure to receive regular reports, the records were incomplete for a few stations in both 1955 and 1956. In 1957 and in the first half of 1958, complete records were obtained for all 14 gages.

Average monthly precipitation for the 14 gages is shown for January 1955 through June 1958 in table 10.

Table 10. - Average monthly precipitation, Kiowa Creek Watershed Protection Project, 1955-58 1/

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1955	0.08	0.44	0.42	0.45	4.15	0.90	1.13	4.29	1.14	0.16	0.17	0.11	13.44
1956	.37	.36	.65	.59	1.53	1.07	2.32	2.27	.27	.33	.97	.42	11.15
1957	.28	.37	.90	4.64	5.54	2.14	4.06	1.67	.78	1.96	.81	.21	23.36
1958	.41	.60	1.40	1.39	4.30	1.98	4.07	1.62	---	---	---	---	---

1/ Unofficial record by Kiowa State Bank at Kiowa for years 1921-54 shows an annual average of 16.0 inches, with a low of 6.91 inches in 1939 and a high of 24.04 inches in 1947.

A detailed analysis of precipitation data for the project has not been undertaken, but complete records are being maintained by the Weather Bureau. Copies of regularly published climatological data are furnished the Soil Conservation Service, together with copies of daily records from both the standard and the recording stations.

Data recorded since the beginning of the project indicate that a few storms have reached intensities approaching 1 inch in a 15-minute period. However, duration of these peak intensities has been relatively short. Although causing runoff, the storms have not created flood conditions, except for the one of July 30, 1957, near the upper reaches. (See p. 26.)

Range systems for measurement of sediment deposition have been established on five reservoirs. It is the intent to remeasure each reservoir periodically or after unusually large inflows. The only reservoir remeasured to date is K-79, which is located below the watershed where, on July 30, 1957, there was an unusually large storm. The storm occurred 1 year after instrumentation was installed, and 2 years after construction. A sedimentation survey made a month later showed the following results: 2/

Sediment deposited in -

Reservoir and delta---------- 2.65 acre-feet
Pool area, 1.1 years---------- 2.39 acre-feet

Capacity depletion, 1.1 years---------- 1.95 percent

Net sediment yield per square mile per year to -

Reservoir and delta---------- .83 acre-feet
Pool area---------- .75 acre-feet

2/ A small stockwater reservoir in the upper watershed about 2 miles above K-79 may have trapped an undetermined amount of sediment.

The design rate for the pool area on a 50-year basis is 0.2 acre-foot per square mile per year. Although the 1-year record, which includes the large storm of July 1957, is not reliable for long-term projection, it does indicate the low erosion potential of the watershed and that the design rate is probably conservative.

Single-stage suspended-sediment samplers that were intended to sample sediment inflow were destroyed by high-velocity water, and therefore no check was possible against the actual measured reservoir volume. These samplers were intended also to provide size distribution of sediment particles and quantity of sediment per unit of water volume. Some data were obtained on sediment concentration of the outflow, and preliminary computations based on these data indicated that about 1,600 tons of sediment had been discharged.

Five samples of deposited sediment in the reservoir and delta were collected at the time of the resurvey. The average dry weight for all samples was 77.6 pounds per cubic foot. Reservoir pool deposits averaged 66.9 pounds per cubic foot and those from the delta averaged 93.6 pounds per cubic foot. The deposits were predominantly sandy, which explains the high volume weight. Mechanical analyses of the five samples of deposited sediment show the following particle-size distribution:

	Gravel (percent)	Sand (percent)	Silt (percent)	Clays (percent)
Reservoir deposits-------	trace	45	34	20
Delta deposits----------	46	53	0	0

Two sediment-load stations are operated under contract with the Geological Survey. One is near Elbert on East Kiowa Creek; the other is south of the town of Kiowa on the main channel. Operation of both stations began on April 19, 1956. Data are collected on daily suspended-sediment discharge, particle-size analyses of suspended sediment and bed material, and rate of water discharge that transports the sediment. In addition, periodic computations of total sediment load are reported.

Reported data are available for part of the 1956 and all of the 1957 water years. Laboratory analyses, computations, checkings, and reviews cause a lag of about 1 year between collection and reporting. The only full year of record at this time is the 1957 water year. Suspended load measured at the Kiowa station was about 100,000 tons for that year. This was transported by about 5,000 acre-feet of runoff. Long periods of no flow were frequent. In 1957, for example, there were only 7 days of flow at the Elbert station. The shortness of the record, and variations between these data and those from earlier observations, indicate that the period covered probably does not represent average conditions.

Instrumentation for determining streamflow and flood stages has not been in operation long enough to provide adequate data for analysis. Records are maintained and evaluations will be made as additional data become available.

Water Table Measurements

In order to observe the effects of the program on the water table in the flood plain, water-level measurements are being taken on 10 irrigation wells. The measurements were started in 1955 and are repeated annually (table 11).

Table 11. - Water table measurements taken on irrigation wells, Kiowa Creek Watershed Protection Project, 1955-57

Location of well	Date drilled	Depth to water 1/				Estimated GPM
		At drilling	1955	1956	1957	
NW¼NW¼ sec. 32, T. 8, R. 63--	1940	23.0	25.3	26.1	22.7	500
SE¼NE¼ sec. 31, T. 8, R. 63--	1947	10.5	10.6	10.3	9.8	130
SE¼SE¼ sec. 30, T. 8, R. 63--	1951	9.9	---	9.5	8.1	130
NE¼SE¼ sec. 10, T. 10, R. 64-	1952	9.8	13.4	14.0	11.5	125
SW¼SW¼ sec. 3, T. 10, R. 64--	1953	7.8	10.6	11.4	7.2	100
SW¼SW¼ sec. 12, T. 9, R. 64--	1952	8.1	8.5	8.7	7.8	400
SE¼SW¼ sec. 32, T. 7, R. 63--	1953	23.0	24.1	25.4	(Not used)	
SE¼SE¼ sec. 1, T. 9, R. 64---	1952	6.4	7.8	7.7	7.1	425
SE¼SE¼ sec. 1, T. 9, R. 64---	1957	16.3	---	---	16.3	400
NW¼SE¼ sec. 12, T. 9, R. 64--	1956	6.0	---	---	---	300

1/ All measurements except "at drilling" taken in December of each year. These are static water levels. The record is insufficient to be conclusive but there is indication of a rising water table in 1957.

Range Plots

As explained on page 18, line-transect readings have been made on all range study plots, and clippings are made annually. It is too soon to identify possible trends or to reach specific conclusions as to changes in range composition and condition.

Economic Effects of Installed Measures

The contract cost of the 34 floodwater-retarding structures that have been completed was $246,621 to the Federal Government and $12,815 to the sponsor. This does not include any technical assistance that may be chargeable to this project. In all, the sponsors have spent more than $65,394 for structures. This includes the cost of the dam built by them, the value of land easements, and costs of road and powerline relocations.

The total cost of land-treatment measures between initiation of the project and June 30, 1958, is estimated at $113,293 (table 12). Needs as of 1954 and quantities applied to June 30, 1958, are listed in table 12. Data on quantities applied are from SCS work sheets, which carry records of all practices applied within the watershed. Prices per unit were based on average costs per county of the Great Plains Conservation Program because information from farmers, obtained annually for a few farms, is not sufficiently adequate to permit evaluation of the costs of different practices. Pasture, and range seeding and range improvement stand out as the major cost items. Using the same basis for estimating, it was found that prior to project inception, needed land-treatment practices costing about $135,320 had been applied.

Total costs of this project to June 30, 1958, excluding technical and overhead costs, are as follows:

Federal costs	$246,621
Sponsoring agency	65,394
Private	113,293
Total	$425,308

Table 12. - Needs as of 1954, and application and cost of land-treatment measures from 1954 to June 30, 1958, Kiowa Creek Watershed Protection Project

Practice	Unit of quantity	Needs in 1954	Applied since 1954		
			Quantity	Price per unit 1/	Cost
				Dollars	Dollars
Pasture and range seeding	Acres	5,900	1,920	15.00	28,800
Contour furrows	do.	4,740	856	2.00	1,712
Range improvement	do.	58,000	35,125	1.50	52,687
Woodland management	do.	10,000	2,372	2.00	4,744
Waterway development	do.	170	21	40.00	840
Erosion-control structures	Number	185	13	115.00	1,495
Livestock-water ponds	do.	35	20	400.00	8,000
Terraces	Miles	50	12	200.00	2,400
Field diversions	do.	60	24	400.00	9,640
Land clearing	Acres	0	70	2/ 42.50	2,975
Fencing	Miles	25	0	---	---
Contour farming, stubble mulch, stripcropping	Acres	3,500	0	---	---
Total cost	-----	---	---	---	113,293

1/ Derived from Great Plains Program average costs.
2/ From farmer estimates of work accomplished.

In addition to this total of $425,308, an appreciable expense is chargeable to this project for technical assistance and evaluation. Exact technical assistance costs cannot be isolated for the 34 structures installed so far, but at project completion they can be accounted for fully.

In the flood plain, farmers are making more productive use of the land because of the reduced flood hazard. Small acreages have been cleared of brush, sand, and even trees, so that the land can be cultivated. Since this project got under way in 1954, nine farms in the sample areas have reported some land clearing or conversion of pasture to hay. By the end of 1957, 70 acres had been cleared and placed under cultivation.

Using actual costs or prevailing rates at the time of land improvement, the total cost to the farmers, including contract work, is estimated at $2,975. Land use changes on the 70 acres accounted for an estimated increase in net income of $761 in 1956 and $1,501 in 1957. The net income was estimated by deducting estimated current cash expenses for the tilled acres each year (52 acres in 1956 and 70 acres in 1957) from the estimated gross value of the crops harvested.

Flood damages prevented by structural measures accounted for $5,190 additional income from crops, and for a reduction of $16,200 in costs of repair to roads, culverts, and dikes. Total benefits attributable to the project through 1957 amounting to $23,652 are summarized in table 13. Benefits from reduction of flood and sediment damage, up to this time, have been tentatively appraised on the basis of information obtained from farmers and estimates of the physical effects of the flood if no works of improvement had been installed.

Table 13. - Flood damages and benefits from flood prevention, 1956 and 1957, Kiowa Creek Watershed Protection Project

Item	1956			1957			Total benefit, 1956 and 1957
	Actual damages	Damages without project	Benefit	Actual damages	Damages without project	Benefit	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Crops and pasture	20	910	890	1,680	5,980	4,300	5,190
Roads and bridges	570	1,570	1,000	775	15,975	15,200	16,200
Dikes	0	0	0	1,200	1,200	0	0
Changed land use	---	---	761	---	---	1,501	2,262
Total	590	2,480	2,651	3,655	23,155	21,001	23,652

No benefits to cropland in the upland sample areas have been evaluated up to this time. The predominance of dry years was not conducive to the installation of the proposed land-treatment measures.

Summary of Report on Storm of July 30, 1957

The only major storm since the beginning of the project occurred on the evening of July 30, 1957, on the subwatershed above structure K-79 near the head of East Kiowa Creek. The storm began about 5:30 p.m. and lasted approximately 45 minutes. Precipitation varying from 0.1 to 0.6 inch had fallen on the subwatershed on 10 of the 12 days immediately preceding the storm.

From both official and nonofficial sources, the extent of rainfall and pattern of the July 30 storm was determined, and an isohyetal map was developed. It showed a 4-inch isohyet about 4 miles long and an average of about 1 mile wide centered near the edge of the subwatershed. The point of maximum rainfall appeared to be about 4½ miles southwest of the structure.

The principal spillway outlet tube of K-79 started functioning at 5:40 p.m., and a peak inflow of 5,880 cubic feet per second was recorded at 6:30 p.m. The emergency spillway started functioning at 6:40 p.m. and continued to operate until about 10:40 p.m. of the same evening. Maximum discharge through the emergency spillway was 1,400 cubic feet per second and at 7:00 p.m. the depth was 2.05 feet. At the same time, the principal spillway was discharging 80 cubic feet per second, giving a total maximum discharge of 1,480 cubic feet per second. At the time of peak discharge, the maximum volume storage of the reservoir was 180 acre-feet. Total volume inflow was 270 acre-feet, of which 107 acre-feet were discharged through the emergency spillway and 163 acre-feet through the principal spillway.

The watershed above reservoir K-79 contains 2,048 acres, exclusive of the reservoir basin itself. The emergency spillway of the structure is 142 feet wide and has a design flow depth of 3.2 feet, assuming the reservoir to be full at the beginning of the storm. Expected inflow rate for a 100-year frequency storm is 3,680 cubic feet per second. Even though the July 1957 storm was not centered over the drainage basin, the maximum inflow of 5,880 cubic feet per second was considerably larger than the maximum expected from a 100-year frequency storm. The structure functioned perfectly with no damage to the structure itself and only minor erosion in the spillway return section near the channel below the dam.

Some significant facts brought out by the storm are:

(1) The storm produced an inflow of 2,200 cubic feet per second in excess of that expected from a 100-year frequency storm.

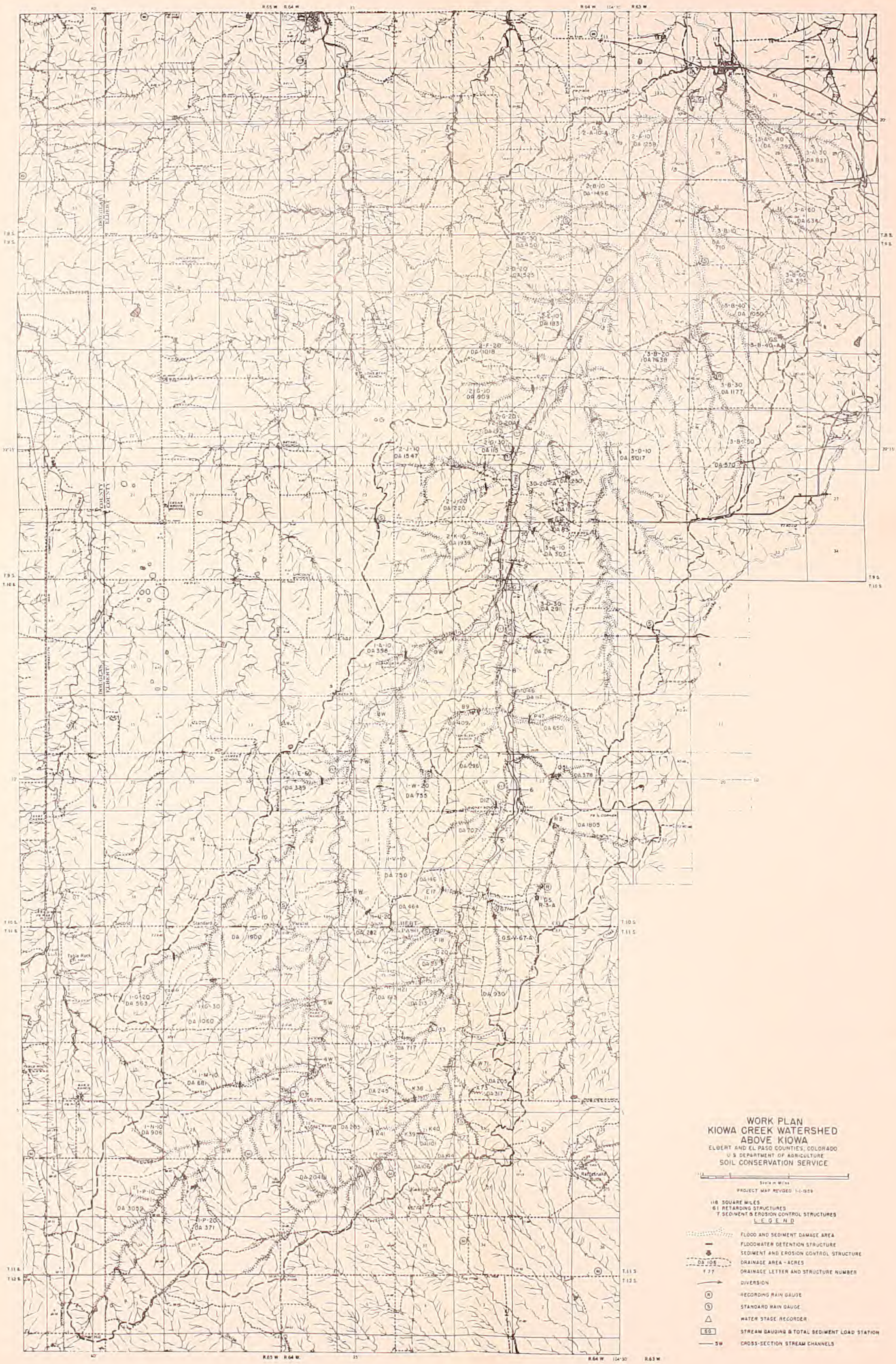
(2) The maximum rate of precipitation was 4½ inches in 45 minutes (unofficial measurements) or a maximum of 6 inches per hour.

(3) Gross erosion on the watershed was calculated at 7.7 acre-feet of sediment, of which 3.5 acre-feet were deposited along stream channels or in a small upstream reservoir and did not reach the main reservoir.

(4) A total of 4.2 acre-feet of sediment or 1.3 acre-feet per square mile of the subwatershed was delivered to the reservoir. This was 55 percent of the sediment resulting from the storm. Of the total sediment delivered, 2.65 acre-feet were retained in the reservoir and delta while about 1.55 acre-feet escaped through the principal spillway.

(5) There was a significant reduction of the flood flow downstream because of the structure.

(6) Calculated reduction of flood damage that would have occurred had not the structure existed was $12,584. Actual damage that did occur was $121, giving a potential storm damage figure of $12,705, of which 99 percent was prevented by the structure.


WORK PLAN
KIOWA CREEK WATERSHED
ABOVE KIOWA
ELBERT AND EL PASO COUNTIES, COLORADO
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Scale in Miles
PROJECT MAP REVISED 1-1-1959
118 SQUARE MILES
61 RETARDING STRUCTURES
7 SEDIMENT & EROSION CONTROL STRUCTURES
LEGEND
FLOOD AND SEDIMENT DAMAGE AREA
FLOODWATER DETENTION STRUCTURE
SEDIMENT AND EROSION CONTROL STRUCTURE
DRAINAGE AREA - ACRES
DRAINAGE LETTER AND STRUCTURE NUMBER
DIVERSION
RECORDING RAIN GAUGE
STANDARD RAIN GAUGE
WATER STAGE RECORDER
STREAM GAUGING & TOTAL SEDIMENT LOAD STATION
CROSS-SECTION STREAM CHANNELS
REVISED 6-19-1959
G-R-13760-8